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Background

Petroleum products stored in underground storage tanks (UST) can present a serious threat to ground water quality. In the past fifteen years, the State of Maine Department of Environmental Protection (DEP) has undertaken an ambitious program to reduce this threat. During the course of this program, the storage system population statewide has been reduced from approximately 42,000 tanks to 5,900. Almost all storage systems in use in the middle 1980's have been replaced.

Since 1985, all new or replacement storage systems installed in Maine have been protected against corrosion by using nonmetallic construction materials such as fiberglass or by using cathodic protection (CP) to prevent corrosion of metallic storage system components. At present, some 1,812 cathodically protected steel tanks are installed in the ground in Maine. This represents just under one-third (31%) of the tank population of approximately 5,900 tanks.

Cathodic protection of buried steel structures is a corrosion protection technique that has been widely used and generally found to be effective. At the present time, almost all of the CP systems in Maine are galvanic. Galvanic CP systems work by creating a corrosion cell where the tank is the cathode and a sacrificial metal, typically zinc, is the anode.

Galvanic CP systems are relatively simple in construction and operation, but it is widely acknowledged that the effectiveness of the CP system must be monitored over time. This monitoring is relatively easy to accomplish by measuring the electrical potential (voltage) of the tank relative to a standard reference (usually a copper/copper sulphate reference electrode).

CP monitoring in Maine has traditionally been conducted by Maine certified tank installers. Installers were required to demonstrate a minimal competency in CP by passing a certification exam which included some questions concerning CP.

DEP regulations have required annual monitoring of cathodically protected storage system components since 1985. Results of the monitoring are required to be kept for three years by the owner of the storage system. In recent years, the DEP has encouraged tank owners to send the results of this monitoring to the DEP, but there is no regulatory requirement to do so.

Because only a small percentage of cathodic protection monitoring results are voluntarily submitted to the DEP, there is little data available on how the cathodic protection systems on these storage tanks are faring. There is anecdotal evidence indicating that

significant numbers of tanks are failing to meet established criteria for cathodic protection. In addition, there are rumors that some cathodic protection monitoring is not being conducted according to proper procedures. As a result, there is little reliable information concerning the corrosion protection status of Maine's cathodically protected storage system population.

Purpose of This Study

Though there have been few reported leak incidents resulting from corrosion failure of cathodically protected tanks, the DEP wanted to determine how the cathodic protection systems on these storage tanks were faring to ensure that they do not become a significant source of leaks in the future. The failure of the cathodic protection system would be expected to precede the failure of the tank via corrosion perforation by a decade or more. In addition the DEP wanted to evaluate whether there were any relationships between the performance of the CP system and various storage tank parameters such as manufacturer, age, or size of the tank.

Specifically, the purpose of this study was to answer the following questions:

- What percentage of cathodically protected storage tanks meet established criteria for cathodic protection?
- How do CP test results from this study compare to CP test results from certified tank installers?
- Is there a relationship between the corrosion protection status of the storage tank and the manufacturer of the tank?
- Is there a relationship between the corrosion protection status of the storage tank and the age of the tank?
- Is there a relationship between the corrosion protection status of the storage tank and the capacity of the tank?
- Is there a relationship between the corrosion protection status of the storage tank and the installer of the tank?
- Is electrical continuity a significant factor in the failure of cathodic protection systems?
- What is the compliance rate with cathodic protection monitoring record keeping requirements?

Based on the answers to these questions, the study is to evaluate:

- whether currently established testing procedures are adequate to fully evaluate the CP status of underground storage tanks,

- whether the data indicate that any specific category of tank (e.g., size, age) should be watched more carefully than the general population, and

- whether modifications to the annual cathodic protection monitoring program should be made to improve its effectiveness.

Study Methodology

The study approach was to conduct cathodic protection monitoring at approximately 75 randomly selected facilities containing cathodically protected tanks.

To select the test facilities, a list of all facilities in the DEP data base containing cathodically protected steel tanks was printed. From this list, which was sorted by county, every tenth facility was marked as a potential candidate for the study. This resulted in a list of 106 facilities to be included in the study. A letter was sent to the owners of these 106 facilities informing them of the study and inviting them to participate. Owners who did not respond to the letter were contacted by telephone. Because participation in the study was voluntary, some facility owners declined to participate. Participants in the study were asked to provide copies of all prior cathodic protection monitoring records. As the study progressed, a few "targets of opportunity" were encountered and included in the study in order to reach the targeted number of facilities.

A total of 75 facilities were evaluated. Two facilities were subsequently removed from the study's data base because field data strongly indicated that the storage tanks at these facilities were jacketed tanks that do not require cathodic protection. The final data base for the study included a total of 134 tanks at 73 facilities. Data from the study are summarized in the table presented in Appendix A.

Only a handful of the facilities evaluated in this study included cathodically protected piping, so data concerning corrosion protection of piping systems are not included in this report.

CP Testing Protocol Used in This Study

The current DEP protocol for CP testing (Chapter 691, Appendix A) requires that measurements be made with the reference cell in contact with soil along the top centerline

of the storage tank. Historically, the DEP has accepted a single potential measurement that is more negative than -.85 volts as an indication that the storage tank is protected against corrosion. Tanks meeting this criterion are generally referred to as "passing" the CP test.

The single reading more negative than -.85 volts accepted by the Maine DEP does not adequately demonstrate that the entire surface of the tank is protected against corrosion. The use of multiple measurements to evaluate a storage tank is consistent with current industry standards. For example, NACE RP0285-95, entitled "*Standard Recommended Practice - Corrosion Control of Underground Storage Tank Systems by Cathodic Protection*" states that,

> Care shall be exercised in selecting the location, number, and type of electrical measurements used to determine the adequacy of cathodic protection. (Section 7.1.4, emphasis added)

Current industry practice indicates that three CP readings should be taken to fully evaluate the corrosion protection status of a storage tank. For example, an article published in the August 2000 issue of Petroleum Equipment and Technology entitled, "*Cathodic Protection - An Effective Answer to the Tank System Corrosion Problem*," states that,

> It is important to take (CP) readings at both ends and the middle of the tank because it is possible that CP can be achieved at one end and not the other. (Page 9).

The CP testing protocol used in this study was more comprehensive than the DEP protocol in that three measurements of the potential, each more negative than -.85 volts, were required to "pass" the CP test. The measurements were made with the reference cell placed at both ends and the middle of the storage tank.

Potential measurements for this study were made with the reference cell in contact with the soil. In cases where the soil was not accessible at three locations over the top of the tank, a half-inch hole was drilled through the asphalt or concrete, and a 3/8 inch "pencil" reference was inserted in the hole to make the measurement.

Except in a handful of cases where the tank did not have a direct fill pipe going straight into the tank, electrical contact with the storage tank was made by inserting a PVC probe with a brass bolt on the bottom end into the tank fill pipe.

In cases where one or more storage systems at a facility failed to meet the -.85 volt criterion, continuity testing utilizing the fixed cell moving ground technique was used to determine whether the storage tank shell was electrically isolated from other storage system components.

All field test data were recorded on forms. A letter documenting the test results was

sent to storage system owners with a copy to the DEP.

Presentation and Discussion of Data

Data from the study were tallied and are graphically presented in Figures 1 through 9. To facilitate reading of the report, the discussion of the data is presented on the page facing each of the figures.

Figure 1. Types of Tanks Included in the Study

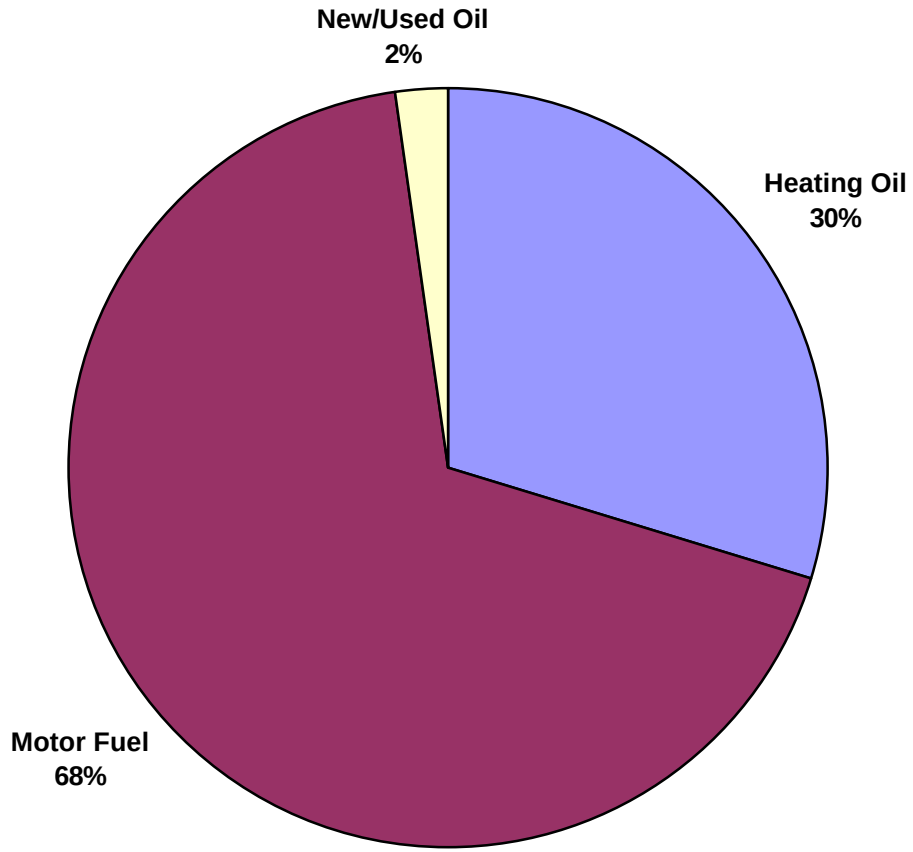

Figure 1. What Types of Tanks Were Included in the Study?

Facility Type	Number	Percent
Consumptive use heating oil	40	30
Motor fuel	91	68
New/Used oil	3	2
TOTAL	134	100

Figure 2. Percentage of Tanks Meeting A Criterion for CP

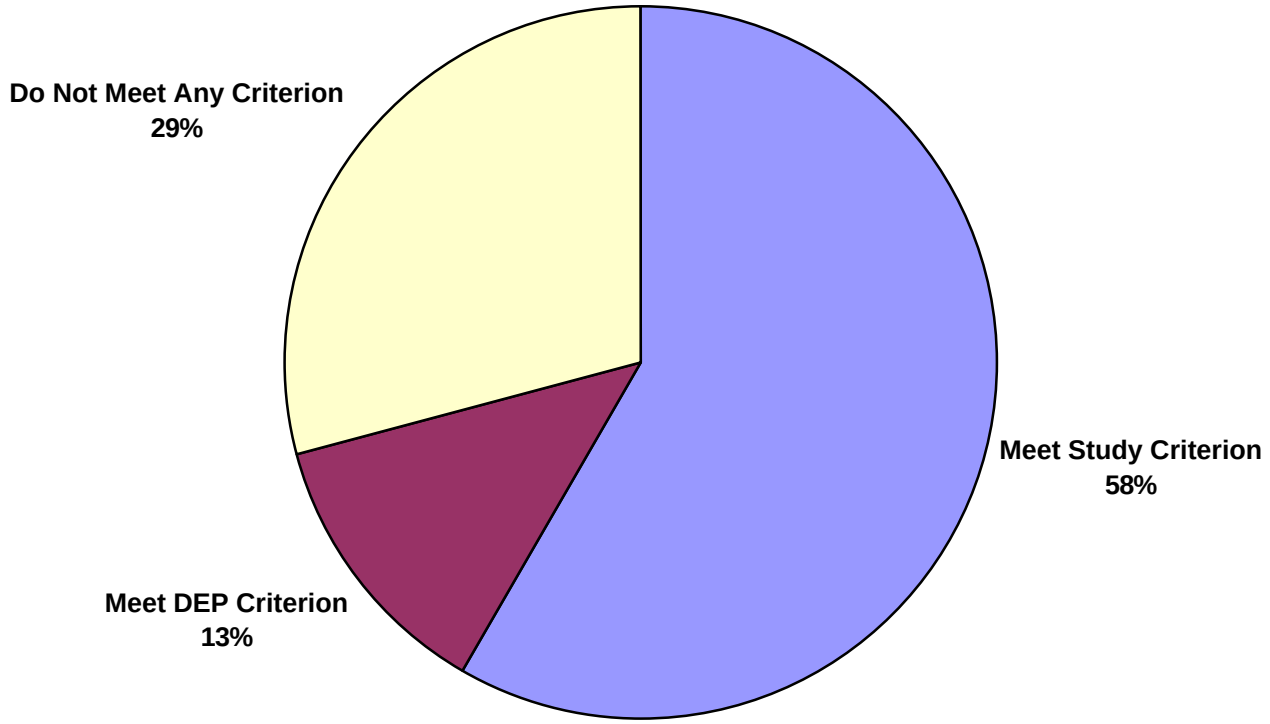

Figure 2. What Percentage of Tanks Meet A Criterion for Cathodic Protection?

Criterion	Number	Percent
Meet study criterion (three potential measurements)	78	58
Meet DEP criterion (one potential measurement)	17	13
Do not meet any criterion	39	29
TOTAL	134	100

For purposes of this study, only storage systems that had a potential more negative than -.85 volts at three points along the top of the tank were considered to be completely protected against corrosion. The DEP presently accepts a single reading more negative than -.85 volts as a passing test. Of the 134 storage tanks tested in this study, 39 failed to have adequate readings anywhere along the top of the tank, 17 tanks met the minimum DEP criterion, and 78 tanks met this study's criterion.

42 percent of the tanks tested in this study failed to meet the criterion of having three passing readings. Extrapolated to the statewide population of cathodically protected tanks, this means that about 760 tanks may not be adequately protected against corrosion. If these tanks are in fact corroding, there could be serious consequences in terms of leaks from these tanks in the future.

Unless otherwise indicated, this study's criterion of three passing readings is used as the basis for determining the pass/fail ratios in the following figures and discussion.

Figure 3. Pass/Fail Ratios for CP Tests by Installers Compared to CP Tests in This Study

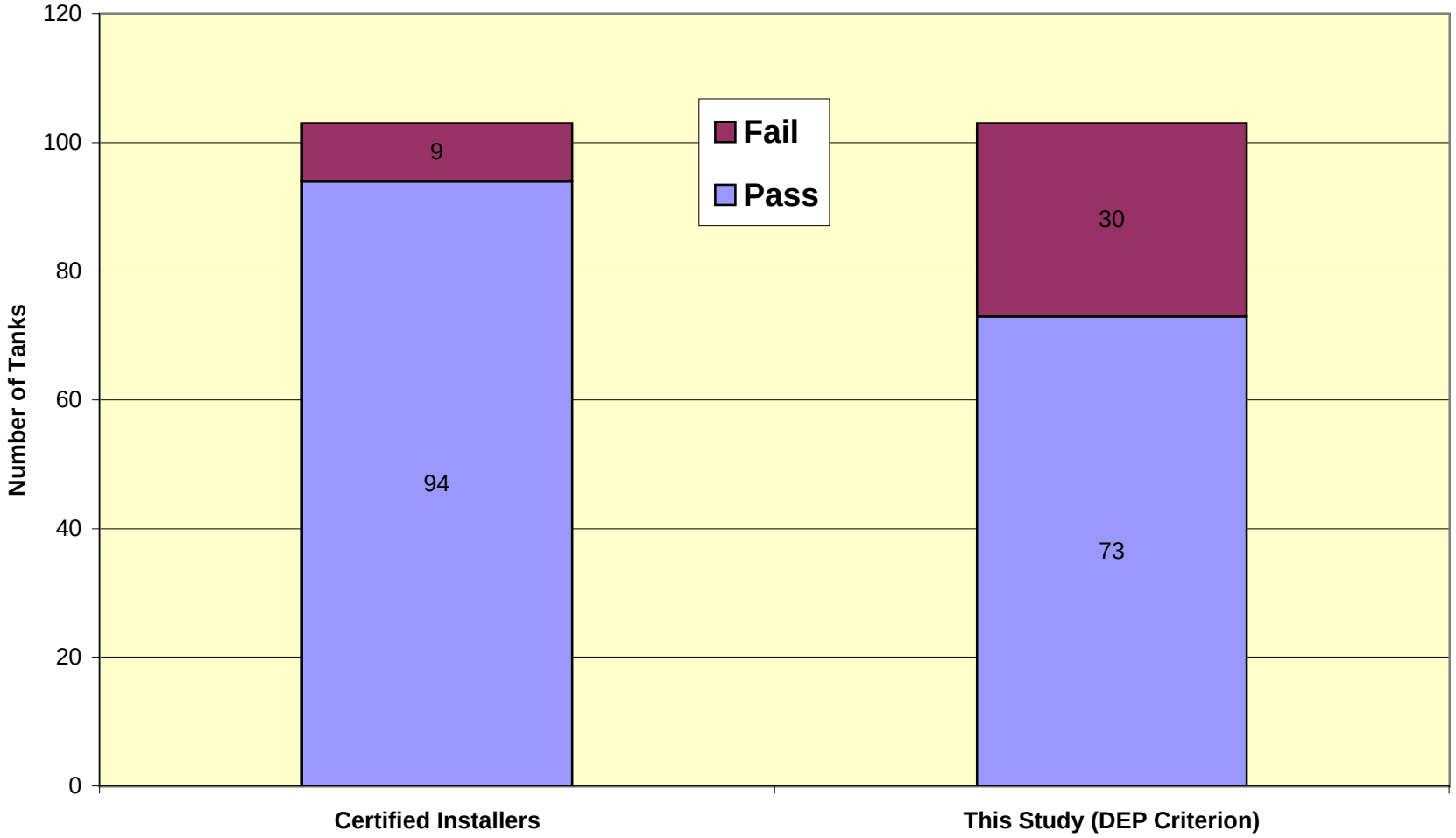

Figure 3. How Do CP Test Results From this Study Compare to CP Test Results From Certified Tank Installers?

CP Test Results According To:	Tanks Tested	Number Passed	Percent Passed
Certified installers	103	94	91
This study using DEP criterion	103	73	71

For those tanks where previous CP test results were available, the results of the previous testing were compared with the results of this study's testing. Because tank installers use the DEP criterion of a single voltage reading to pass or fail a tank, the DEP criterion was applied to this study's data to determine the pass/fail status of the tank. Three tanks were eliminated from this comparison because it was known that anodes had been added to the tank between the time of the installer test and this study's test.

Certified tank installers passed a much larger percentage of tanks than the CP testers in this study. The possibility that this was due to the lapse of time between testing by the certified installers and the testing conducted for this study was considered, but this factor alone is not sufficient to explain the difference. The time elapsed between testing events is summarized in the table at the right. The "0" year column indicates that both tests were conducted in the same calendar year. The majority of the tests where results differed were conducted a year or less apart. In addition, age of the tank was not found to significantly affect the CP test pass/fail ratio (See Figure 5). Thus a large part of the difference in the percentage of tanks passed is most likely due to a difference in the testing methodologies used by certified installers and the CP testers in this study.

Time Elapsed (years)	0	1	2	3	4

This finding tends to corroborate anecdotal reports of installers placing the reference cell in every possible location until a “passing” reading is obtained. It was also observed in this study that a number of facilities have unlabeled wires that often give “passing” readings, though in many cases these wires are not connected to the tank shell. Again, anecdotal evidence points to installers using these wires as test wires without verifying that the wires are actually connected to the tank. It is clear that the CP test procedures practiced by certified installers need improvement.

It should also be noted that there were two instances where tanks that had failed CP tests conducted by certified installers earlier in the year passed the CP test conducted as a part of this study.

Figure 4. Pass/Fail Ratio by Tank Manufacturer

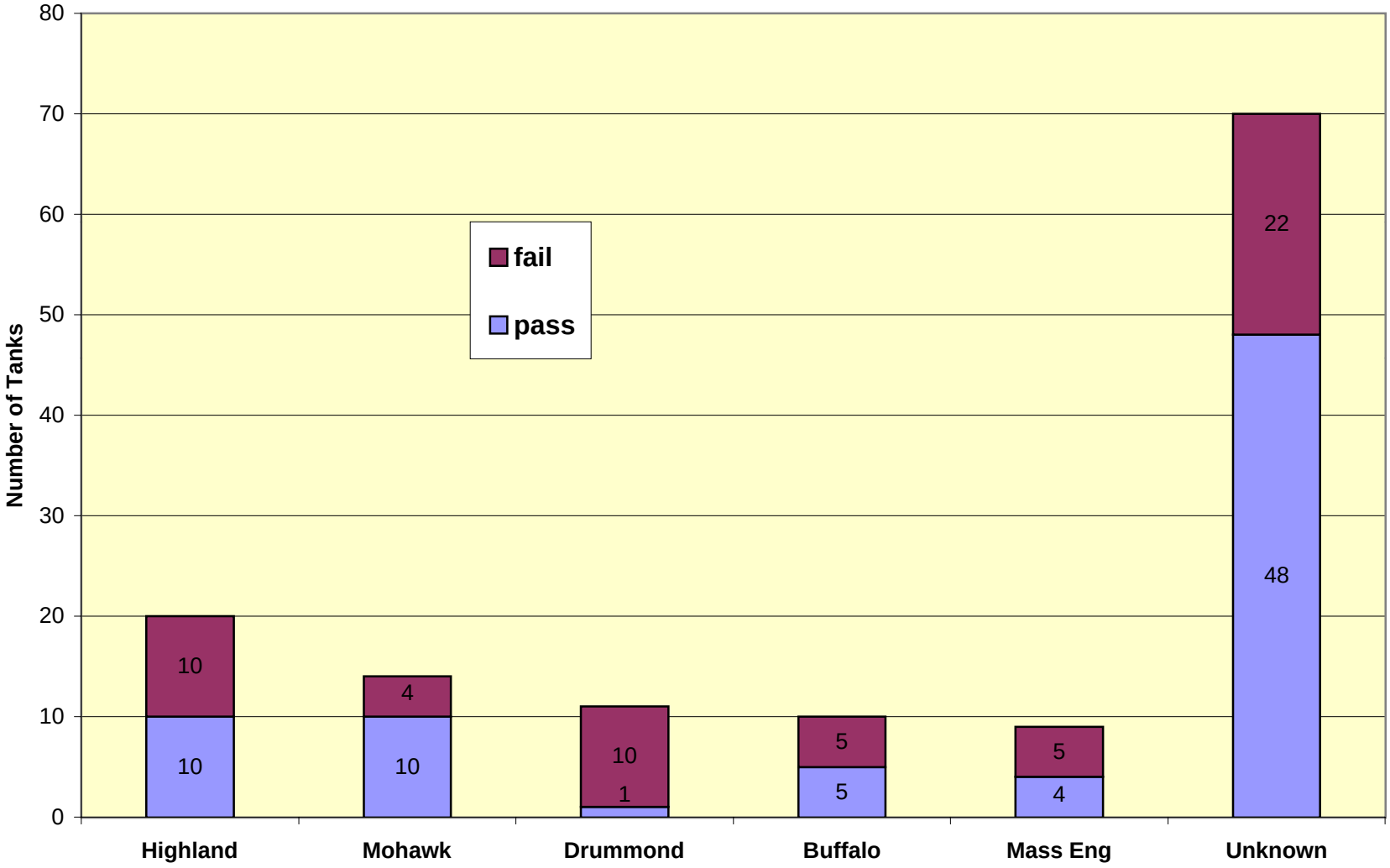

Figure 4. Is There A Relationship Between the Corrosion Protection Status of the Storage Tank and the Manufacturer of the Tank?

Manufacturer	# Pass	# Fail	Percent Pass
Highland	10	10	50
Mohawk	10	4	71
Drummond	1	10	9
Buffalo	5	5	50
Massachusetts Engineering	4	5	44
Unknown	48	22	69
TOTAL	78	56	58

Seventy percent of the present day owners of the storage tanks did not know the manufacturer of their storage tank. As a result, the sample size per manufacturer is quite small and little can be said concerning pass/fail trends for a specific manufacturer. It does appear that the pass/fail ratios for individual manufacturers are generally consistent with the overall pass/fail ratio. One possible exception is Drummond, which had a relatively small percentage of passing tanks.

Drummond is a Canadian tank manufacturer that imported a significant number of cathodically protected tanks into Maine in the mid to late 1980's. In that time period, the Canadian standard for applying cathodic protection to a steel tank differed from the American standard. Differences in the two standards may account for the relatively small percentage of Drummond tanks that passed the study criterion for cathodic protection.

Massachusetts Engineering and Buffalo Tank are no longer in business. Mohawk is no longer in the tank fabricating business, and Drummond does not appear to be importing tanks into Maine any longer. Highland is the only remaining active steel tank manufacturer of those listed in the table above.

Figure 5. Pass/Fail Ratio by Year of Installation

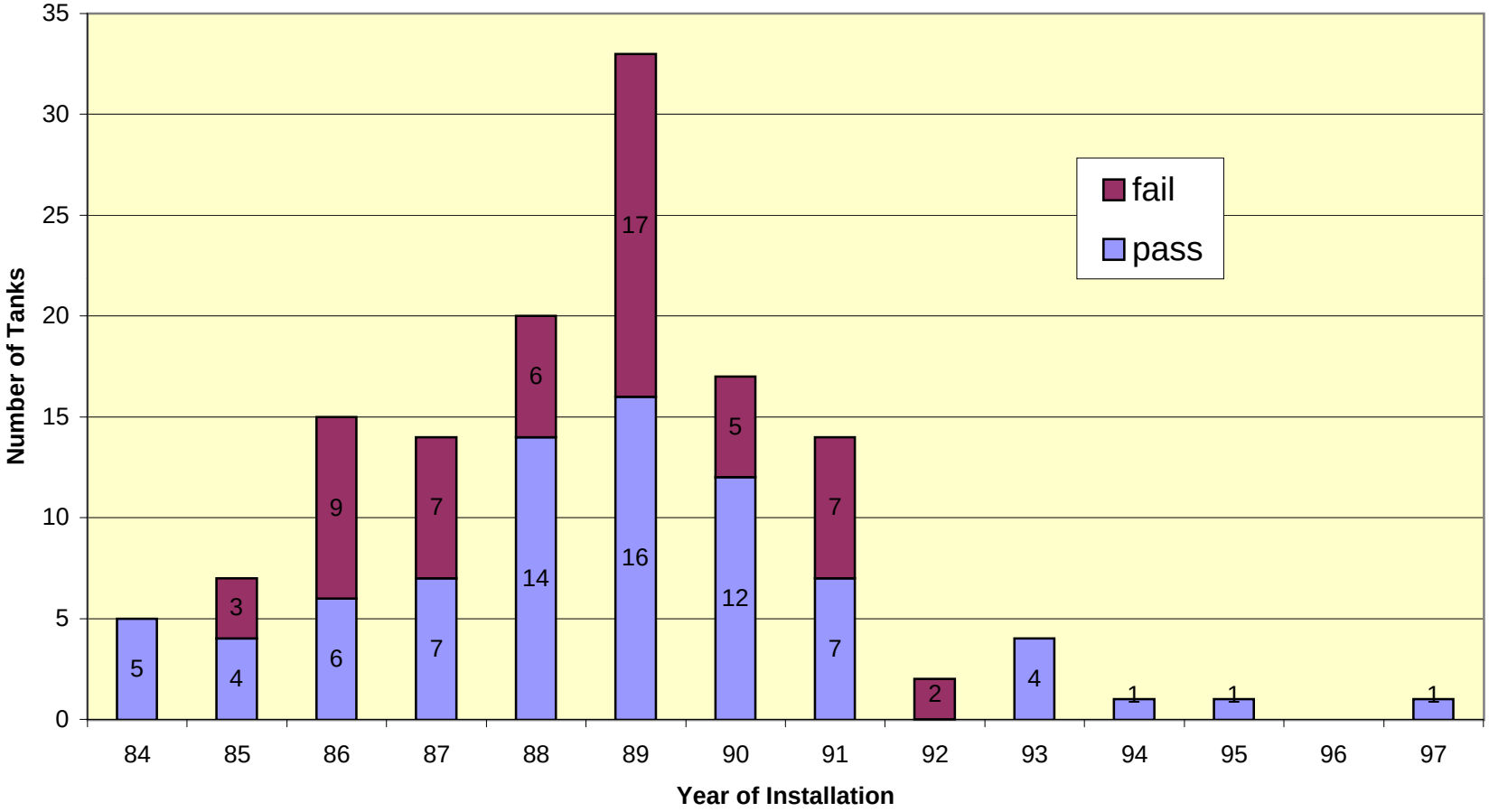

Figure 5. Is There A Relationship Between the Corrosion Protection Status of the Storage Tank and the Age of the Tank?

Because of the relatively small numbers of tanks installed in any given year, not much can be said about the performance of the CP systems over time. It does appear that the pass/fail ratios for most years are generally consistent with the overall pass/fail ratio of the study population of 58 percent. The high percentage of passing tanks for 1984 is explained by the fact that three of the five tanks had additional anodes added in 1998. The seven tanks installed since 1993 are also faring well, but the sample size is too small to say anything definitive.

Year Installed	# Pass	# Fail	Percent Pass
84	5	0	100
85	4	3	57
86	6	9	40
87	7	7	50
88	14	6	70
89	16	17	48
90	12	5	71
91	7	7	50
92	0	2	0

Because galvanic anodes are consumed over time, galvanic cathodic protection sys- tems have a finite life expectancy. It is to be expected that older systems would fail a CP test more frequently than younger systems.

This does not appear to be the case for the population of storage tanks in this study. This may be because properly installed and operating CP systems have not aged beyond the design life of the CP system (30 years), so these systems have not yet passed beyond the time when the anodes would be expected to be expended. Possible reasons for failing CP tests other than consumption of the anodes include natural factors such as soil resistivity, installation factors such as failure to achieve electrical isolation, and manufacturing factors such as degradation of the coating. Except for electrical isolation, these potential failure factors were not investigated during this study.

Figure 6. Pass/Fail Ratio by Tank Capacity

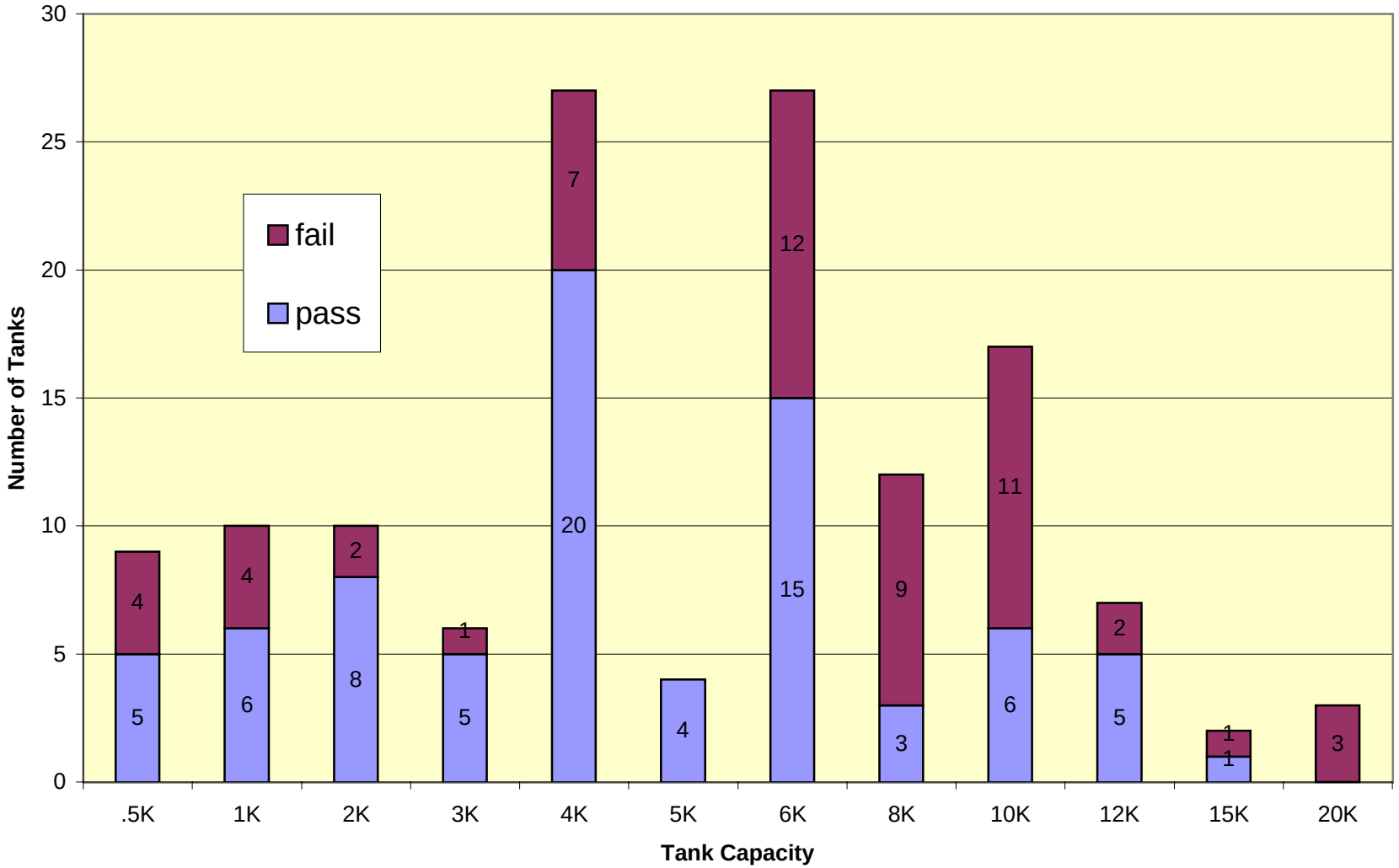

Figure 6. Is There a Relationship Between the Corrosion Protection Status of the Storage Tank and the Capacity of the Tank?

Tank Capacity	# Pass	# Fail	Percent Pass
.5K	5	4	56
1K	6	4	60
2K	8	2	80
3K	5	1	83
4K	20	7	74
5K	4	0	100
Subtotal	48	18	73
6K	15	12	56
8K	3	9	25
10K	6	11	35
12K	5	2	71
15K	1	1	50
20K	0	3	0
Subtotal	30	38	44
TOTAL	78	56	58

There appears to be a significant difference in the pass/fail ratios of smaller tanks versus larger tanks. 73 percent of tanks less than 6,000 gallons in capacity passed the CP test, while only 44 percent of tanks 6,000 gallons and over passed the CP test. Larger tanks have a potentially greater surface area to protect and have areas of the tank that are further away from the anodes than smaller tanks. These factors may contribute to the observed difference in the CP test performance of large versus small tanks.

Figure 7. Pass/Fail Ratio by Tank Installer

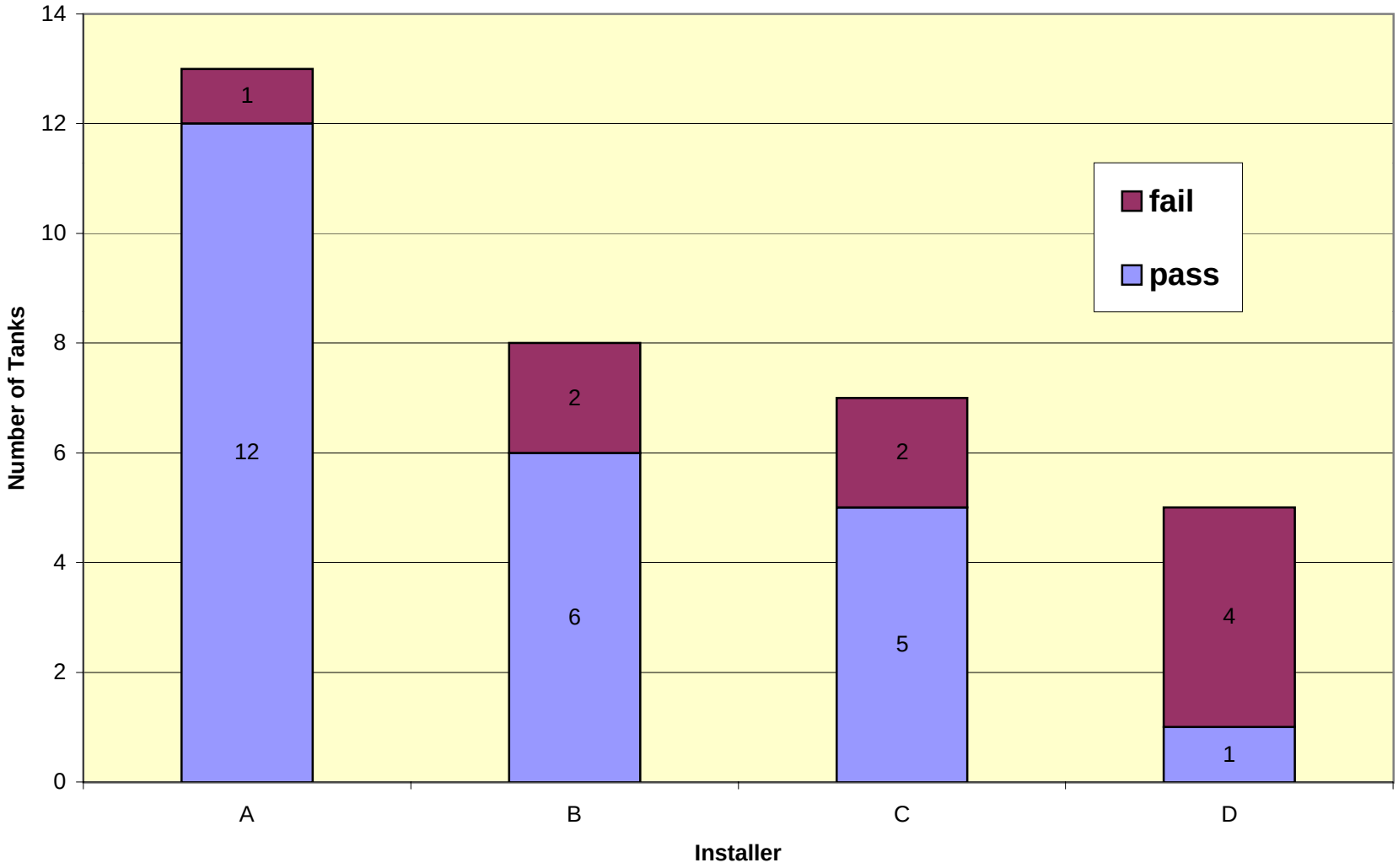

Figure 7. Is There A Relationship Between the Corrosion Protection Status of the Storage Tank and the Installer of the Tank?

Installer	# Pass	# Fail	Percent Pass
A	12	1	92
B	6	2	75
C	5	2	71
D	1	4	20
TOTAL	24	9	73

One of the factors that may influence the performance of CP systems is the care with which they are installed. The installer certification number was recorded in the DEP tank data base for 50 of the facilities that were evaluated in this study. A total of 38 different installers were responsible for installing these 50 facilities. The CP test results for installers who had installed five or more tanks are presented in the table above. The data hint at the possibility that the installer may have a significant influence on the long term performance of the CP system, but the data for individual installers are too sparse to draw any firm conclusions.

Figure 8. Status of Electrical Continuity for Failed CP Tests

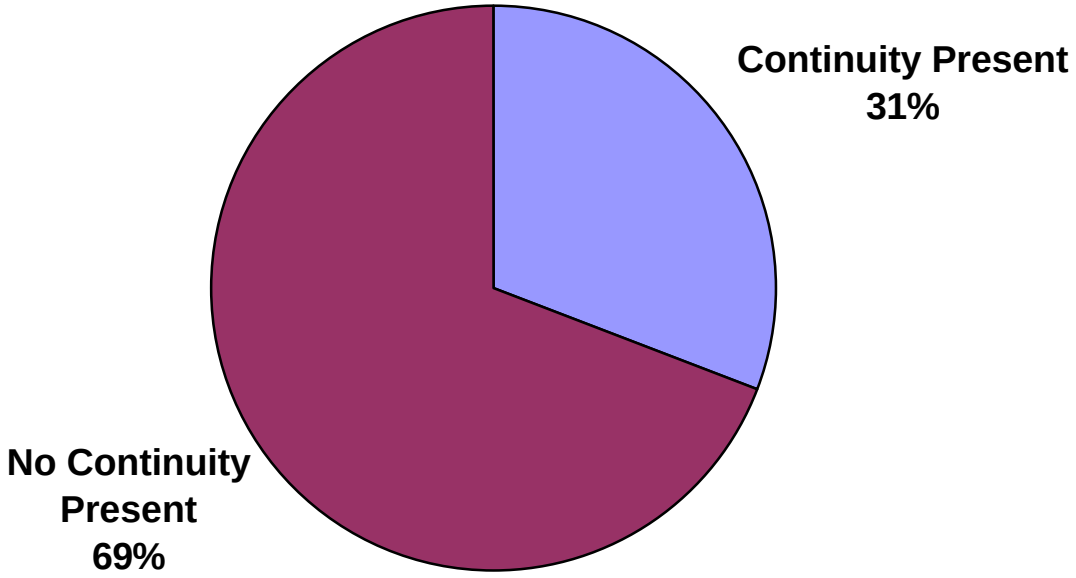

Figure 8. Is Electrical Continuity a Significant Factor in the Failure of Cathodic Protection Systems?

Galvanic anodes are able to protect only a limited surface area of metal exposed to soil moisture, but they will attempt to protect any buried metal to which they are electrically connected. Therefore, to ensure the longevity and effectiveness of galvanic CP systems, it is important to isolate electrically the metal that is to be protected from all other buried metal. This is typically accomplished by inserting nylon bushings into the tank openings so that any metallic components screwed into the tank openings are not electrically continuous with the tank shell. While the nylon bushings are fairly effective, metallic electrical conduit or metallic anchoring hardware (installed to keep a tank from floating out of the ground in high groundwater conditions) that accidentally contacts the tank can result in electrical continuity of the tank shell with a great deal of extraneous metal. This will overtax the galvanic anodes and typically result in failing CP test readings.

	Number	Percent
Continuity present	13	31
No continuity present	29	69

For tanks with passing readings, it was assumed that electrical continuity was not a problem. Tanks that failed the CP test were tested for electrical continuity by positioning the reference cell in a central location and checking all accessible metal (fill pipes, vent pipes, product piping, electrical conduit, etc.) that might possibly be in contact with the tank to see if the voltage matched that of the tank shell. Metal structures with voltages within a few millivolts of the tank shell were judged to be continuous with the tank shell. Because anchoring hardware is not normally accessible without excavation, continuity with anchoring hardware was not evaluated as a part of this study. At some facilities continuity testing was not conducted because of inability to access metallic piping, time constraints, or adverse weather conditions (e.g., pouring rain).

Electrical continuity testing was performed on 42 failing tanks. Continuity problems were identified for 13 (31%) of these tanks. While electrical continuity with accessible tank components can account for nearly one-third of the CP test failures, additional factors such as continuity with anchoring hardware, coating defects or deterioration, high soil resistivity, or other installation related problems are likely contributing to the failure of the remaining two-thirds of the tanks to meet the CP criterion used in this study.

Figure 9. Compliance with CP Record Keeping Requirements

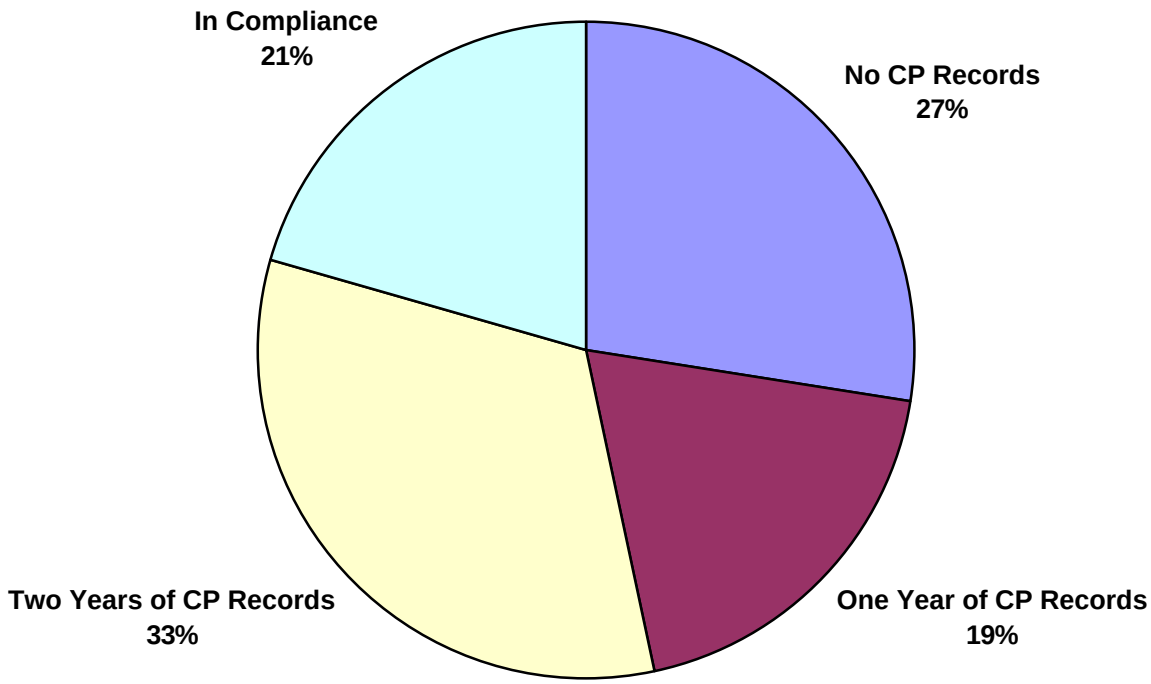

Figure 9. What is the Compliance Rate With Cathodic Protection Monitoring Record Keeping Requirements?

Facilities with:	Number	Percent
No CP test results	20	27
One year of CP test results	14	19
Two years of CP test results	24	33
Three years of CP test results (in compliance)	15	21
TOTAL	73	100

DEP regulations include a requirement to retain various maintenance and leak detection records, including cathodic protection monitoring records, for at least three years. As part of this study, tank owners were asked to provide all available cathodic protection monitoring data. Some owners were able to produce old records but not recent ones, some produced only one or two years of records from the last three years.

The table above shows the distribution of records produced by the owners of the facilities in this study. Only records from the last three years (97/98/99 or 98/99/00, depending on the date of the most recent test) were included as records documenting compliance. Only 20 percent of facilities were found to be in full compliance. While some facility owners may have had testing conducted but have not retained or produced the paperwork associated with the testing, there seems little doubt that many facilities have their cathodic protection testing conducted infrequently, if at all.

Results

This study was intended to answer the following eight questions concerning the status of cathodically protected underground storage tanks in Maine:

What percentage of cathodically protected storage tanks meet established criteria for cathodic protection?

> Of the 134 tanks included in this study, 78 tanks (58%) met the study criterion of having all readings taken along the top of the tank more negative that -.85 volts. An additional 17 tanks (13%) in the study population met the less stringent DEP criterion of having at least one reading taken along the top of the tank more negative than -.85 volts. 39 tanks (29%) of the study population did not meet any criterion for cathodic protection.

How Do CP Test Results From this Study Compare to CP Test Results From Certified Tank Installers?

> While certified installers passed 91 percent of the tanks that they tested, this study found a significantly lower passing rate of 71 percent, utilizing the DEP criterion of a single passing reading.

Is there a relationship between the corrosion protection status of the storage tank and the manufacturer of the tank?

> Because of the large number of tanks where the manufacturer was unknown, this study was not able to determine any significant relationship between corrosion protection performance and the manufacturer of the tank.

Is there a relationship between the corrosion protection status of the storage tank and the age of the tank?

> The data from this study do not indicate that there is any significant relationship between the age of the tank and the corrosion protection status of the tank.

Is there a relationship between the corrosion protection status of the storage tank and the size of the tank?

Forty-four percent of tanks with a capacity of 6,000 gallons and larger met the study's criterion for adequate cathodic protection, while 73 percent of tanks less than 6,000 gallons in capacity met the study's criterion. The data indicate that smaller tanks are more likely to pass the CP test criterion used in this study than larger tanks.

Is there a relationship between the corrosion protection status of the storage tank and the installer of the tank?

The data hint at the possibility that the installer may have a significant influence on the long term performance of the CP system, but the data are too sparse to draw any firm conclusions.

Is electrical continuity a significant factor in the failure of cathodic protection systems?

Electrical continuity testing was performed on 42 failing tanks. Continuity problems were identified for 13 (31%) of these tanks. While electrical continuity is the likely cause of CP test failure for nearly one-third of the tanks tested, other factors are likely responsible for the failure of the remaining two-thirds of the tanks to meet the cathodic protection criterion used in this study.

What is the compliance rate with cathodic protection monitoring record keeping requirements?

Of the 73 facilities included in the study, 20 (27%) have no CP testing records, 14 (19%) have one year of record, 24 (33%) have two years of records, and only 15 (21%) have the required three years of CP monitoring records.

Discussion

Are Currently Established Testing Procedures Adequate to Fully Evaluate the Status of Underground Storage Tanks?

The Current CP Testing Protocol is Inadequate.

This study documented 17 instances where portions of a tank met the -.85 volt criterion for cathodic protection, but other portions of the tank did not. Because a reference cell placed at grade is approximately three feet away from the tank shell, the reference cell at a given location is "seeing" only a portion of the entire tank surface. Because corrosion on a well-coated tank is likely to occur only around localized defects in the coating, the reference cell must be placed at different locations along the top of the tank in order to accurately evaluate the entire top of the tank.

Ideally, the reference cell should be placed at several locations along the bottom of the tank as well, but this is not practical. Instead, the assumption is made that if the top surface of a tank is protected, then the rest of the tank is most likely protected as well. This is a reasonable assumption because the top of the tank is the portion of the tank that is furthest from the anodes and is likely to be the most difficult to protect.

On large tanks, anodes may not produce sufficient voltage to protect the portions of the tank that are more remote from the anodes. Substantial defects in the tank coating, high resistance backfill or problems with the anodes (e.g., failure to remove anode packaging) may also result in portions of the tank failing to receive sufficient protective current to meet the -.85 volt criterion.

The single reading more negative than -.85 volts required by Maine DEP regulations (Chapter 691, Appendix A) to pass a test does not adequately demonstrate that the entire surface of the tank is protected against corrosion. As noted in the description of the CP testing protocol used in this study (Page 4), the use of multiple measurements to evaluate the status of a tank is consistent with current industry standards and practice.

The Current Level of Knowledge of Certified Installers with Regard to CP Testing is Inadequate.

There were significant differences in the percentage of passing tanks when

tested as part of this study and when tested by certified installers. While in a few cases this may be attributable to the testing for this study occurring at a significantly later date than the testing by the certified installer, I believe that in many cases the difference is attributable to improper test procedures utilized by some certified installers. For example, measurements must be made with the reference cell in contact with soil rather than concrete, and measurements using unidentified wires cannot be assumed to indicate the status of the tank. Certified installers who wish to provide CP testing services should receive additional training to ensure that they know how CP testing should be conducted.

Conversations with several tank owners during the course of this study indicated that many certified installers are unsure how to proceed when a storage tank fails a CP test. Installer training should specifically include troubleshooting procedures and evaluation procedures so that installers who provide CP testing services are more knowledgeable in recommending remedies for failing CP systems to tank owners.

Should Any Specific Category of Tank be Watched More Carefully Than the General Tank Population?

The data gathered by this study indicate that there is no basis for focussing attention on storage tanks based on manufacturer or age of the tank. Tanks of 6,000 gallon capacity and larger may bear watching as the study data indicate that they are more prone to failing the CP test than smaller tanks. However, if the general recommendations of this study are implemented for all tanks, there should be no need to focus any additional attention on larger capacity tanks.

Should Modifications to the Annual Cathodic Protection Monitoring Program be Made to Improve its Effectiveness?

Annual testing of cathodic protection systems is important to the long term integrity of steel storage tanks and the protection of Maine's groundwater resources. Forty-two percent of the CP tanks in the state are of single walled construction, making it doubly important that the integrity of the tank wall be maintained for the life of the tank. The following paragraphs describe changes to the existing program that would improve its effectiveness in protecting human health and the environment.

<u>Change the Program to Increase CP Testing Compliance</u>

A quarter of Maine's facilities with cathodically protected steel tanks do not appear to be doing any testing at all, and half of the facilities are doing testing only sporadically. To facilitate enforcement of the cathodic protection testing requirement, DEP regulations should be amended to require that copies of the test results be submitted to the DEP for review.

This would require little extra effort on the part of tank owners who are having CP systems tested, but it would greatly facilitate the ability of the DEP to identify facility owners who are not complying with the rules. In addition, storage tanks with failing results could be quickly identified and the DEP could monitor actions taken to repair the cathodic protection system. For maximum effectiveness, DEP personnel should have a solid understanding of CP systems and CP testing procedures so that they can knowledgeably review the paperwork that is submitted.

Testing of cathodic protection systems is often conducted at the same time as the annual test of operation of leak detection equipment also required by DEP regulations. Like the CP monitoring results, there is presently no requirement to submit the results of this operational inspection to the DEP. A study of the annual inspection reports conducted earlier this year ("*Study of Maine Underground Storage System Annual Inspection Reports*," by Marcel Moreau Associates, July 2000) has recommended that regulations be amended to require that these inspection results be submitted to the DEP. Requiring that both annual inspection results and CP test results be submitted to the DEP would benefit both programs. Linking the ability to receive fuel to compliance with the annual leak detection equipment test requirement, as proposed in the study mentioned above, would also help ensure that tank owners comply with the CP test requirement.

<u>Change the Program to Update CP Testing Procedures</u>

It is likely that many tanks passing the DEP criterion for cathodic protection are not fully protected against corrosion. Appendix A of Chapter 691 has remained relatively unchanged since the first edition of the rules in the middle 80's. If my memory serves me well, I was a principal author of Appendix A in the original edition of the regulations. In the intervening years I have gained a greater understanding of the complexity of cathodic protection monitoring, and have come to recognize that Appendix A in its current form is not enough. Appendix A should be updated to provide more guidance in how measurements should be done, how they should be documented and how many measurements should be made to thoroughly evaluate a

storage tank.

Change the Program to Increase Knowledge Level of CP Testers

Most certified installers in Maine have a rudimentary knowledge of how to make CP measurements, but are stymied whenever failing readings are encountered. Their troubleshooting skills are minimal and they are generally not familiar with techniques that can be used to evaluate whether a storage system merely needs additional anodes or whether an impressed current cathodic protection system will be needed to adequately correct the problem.

The general level of knowledge of installers who are testing cathodic protection should be increased so that storage system owners can more accurately be informed of the nature of the problem with their storage tanks and what their options are for repairing the CP systems. The DEP currently administers a program of tank installer certification. The DEP might consider creating and administering another category of tank worker certification, "cathodic protection tester" that would be specifically established for installers who wanted to do CP testing work.

Alternatively, DEP regulations could be modified to require installers who wish to provide CP testing services to demonstrate that they are knowledgeable about CP testing practices. Such knowledge could be demonstrated by achieving certification from an existing independent organization such as NACE International, International Fire Code Institute (IFCI), or other training provider previously approved as adequate by the DEP. If this option is chosen, the DEP should take care to approve only those certification programs that are specifically targeted to the testing of CP on underground tank systems as opposed to cross country pipelines. The DEP should also verify that the certification requirements include knowledge of CP troubleshooting procedures.

Change the Program to Provide Financial Assistance to Tank Owners Who Must Repair CP Systems

This study indicates that more thorough testing of all CP systems will result in the discovery of a large number of "failing" systems. While a failing CP test does not mean that a leak is occurring or even imminent, it is important that the CP system be quickly repaired to ensure the long term integrity of the tank.

Repairs to CP systems typically cost from a few thousand dollars for the

addition of supplemental galvanic anodes to six or seven thousand dollars for the installation of an impressed current cathodic protection system. Many of these storage systems are owned by small businesses, school districts and municipalities who might be hard pressed to afford the repairs. Consideration should be given to providing financial assistance via state agencies (e.g., Finance Authority of Maine) to assist tank owners in repairing their storage systems in a timely and affordable manner.

Change the Program to Assess the Condition of Excavated Tanks

While CP testing provides an estimate of the corrosion status of a tank, it would be useful to know conclusively how cathodically protected storage systems are faring over time. Cathodically protected storage systems are occasionally removed from the ground for various reasons. A detailed visual evaluation of the physical condition of the storage tank at the time of excavation could provide much useful information on whether cathodic protection systems are functioning as intended or not.

Comparison of the CP test records to the condition of the tank would be useful in evaluating the effectiveness of CP testing in determining the condition of the tank. Over time, a data base could be accumulated that could be useful in predicting the performance of the cathodically protected tank population in Maine.

For consistency purposes, a tank evaluation protocol should be developed that would list the procedures to be used in evaluating a tank. The evaluation protocol could specify what background data should be gathered, what pictures should be taken, how the tank should be examined, etc. The actual evaluations could then be conducted by DEP personnel or by qualified subcontractors or tank removers.

Recommendations

Specific recommendations to assist in executing the program changes described above are as follows:

1) Require that results of the annual CP testing be submitted to the DEP. A minimum standard for CP test documentation should be established so that sufficient information is provided on the report form to evaluate the test procedure and the test results. The DEP should ensure that knowledgeable staff are available to review the results and follow up on questionable testing practices, failing test results and repair procedures.

2) Revise Appendix A of Chapter 691 to provide a more comprehensive evaluation of cathodically protected storage systems. The Appendix should specify the number of readings that should be taken for various sizes of storage tanks. Three readings should suffice for most tanks, though more readings might be required for large capacity tanks. All required readings should be more negative than -.85 volts for the CP system to be judged adequate. Troubleshooting and corrective measures for tanks that do not meet the -.85 volt criterion should be more precisely described, and a definite timetable for the repair of the CP system should be specified.

3) Amend regulations to require that all personnel who wish to provide CP testing services provide documentation of knowledge of CP testing practices specific to underground storage tank systems. The DEP may wish to establish an in house program of certification or may choose to approve outside organizations to provide the training and certification of personnel who wish to provide CP testing services.

4) Establish a program to provide financial assistance to tank owners who face substantial expenditures to repair their CP systems.

5) Undertake a long term study of the performance of cathodically protected storage systems. This could be accomplished by conducting visual inspections at the time of storage system removal and documenting the condition of the tank shell, tank coating, remaining anode weight, etc. A protocol should be developed that can be implemented by DEP staff, outside consultants or certified tank removers.

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Appendix A

Data Summary Table